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2019-04-03

Toppinen , A M K , Sauru , M E , Pätäri , S , Lähtinen , K & Tuppura , A 2019 , ' Internal and external factors of competitiveness shaping the future of wooden multistory construction in Finland and Sweden ' , Construction Management and Economics , vol. 37 , no. 4 , pp. 201-216 . https://doi.org/10.1080/01446193.2018.1513162

http://hdl.handle.net/10138/303756
https://doi.org/10.1080/01446193.2018.1513162

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acceptedVersion

# Internal and external factors of competitiveness shaping the future of wooden multistorey construction in Finland and Sweden

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## ABSTRACT

In transitioning to a renewable material-based bioeconomy, growing public and industry interest is apparent for using wooden multistorey construction (WMC) as a sustainable urban housing solution in Europe, but its business implications are not well understood. In our study, we evaluate, which internal and external factors of competitiveness are shaping the future of WMC, especially in the context of Finland and Sweden. Based on a multi-level perspective of socio-technical transitions, we conducted a three-stage dissensus-based Delphi study. The identified internal and external factors affecting the future competitiveness of the WMC business emphasize the importance of skilled architects and builders and the role of standardized building systems. Based on our results, the key aspects influencing the future competitiveness of WMC in the region are related to the development of technical infrastructure and project-based business networks, while additional changes in regulatory framework are perceived as less important. We conclude that towards 2030, the strong cognitive rules founded in the concrete-based building culture in these countries is likely to inhibit the dynamics of the socio-technical regime level. A change is also needed in the WMC business culture towards more open cross-sectoral collaboration and new business networks between different-sized players.

Keywords: wood, business networks, Delphi method, competitiveness

## Introduction

The construction sector is one of the main fields of economic activity in the European Union in terms of final energy consumption, greenhouse gas emissions, material extraction and water consumption (European Commission 2011). Discourse concerning the benefits of choosing wood material to implement green building solutions (Wang *et al.* 2014, Darko *et al.* 2017, Toppinen *et al.* 2018) has therefore emerged as a method for tackling sustainability problems and enhancing, for example, the resource and carbon efficiencies of material choices and the energy efficiency of buildings. In transitioning to a renewable resource-based bioeconomy (for a definition, see European Commission 2012), growing public and industry interest is apparent towards using wooden multistorey construction (WMC) as a sustainable urban housing solution, especially in Northern Europe (Bosman and Rotmans 2016). Despite this, its implications and future prospects are not yet understood with the exception of a few studies (such as Hurmekoski *et al.* 2018, Toppinen *et al.* 2018), giving impetus for our study.

The European-wide industry goal for wood construction includes tripling the share of WMC from 2015 until 2030 (Forest Sector Technology Platform 2012, hereafter FTP). The supporting role of regulatory environment (such as a "pro-wood" thinking) has been emphasized as an enabling factor for the WMC sector development towards the future (Toppinen *et al.* 2018). Despite recent growing public and industry interest in WMC as a sustainable urban housing solution, and the positive signs of related regulatory frameworks, the prospects for future market diffusion are not overly positive according to Hurmekoski *et al.* (2018). For example, the market share of wooden multistorey apartment buildings completed in Finland only increased from 1% to 6% between years 2010–15, despite intense promotional work and significant changes in building codes.

Increasing the share of WMC is hindered by the strong path dependencies of concrete building networks (Mahapatra and Gustavsson 2008, Hemström *et al.* 2017). Furthermore, Nordin *et al.* (2010)

concluded that re-structuring WMC business networks could partly solve the issue of a narrow WMC niche. According to Nordin et al. (2010), re-structuring comprises changing both internal (e.g. more collaboration with suppliers, on-site contractors and engineered wood product manufacturers to develop off-site construction methods) and external factors (e.g. implementation of R&D efforts with organizations and associations developing technical standards) affecting the WMC business.

A multi-level perspective approach (MLP) by Geels (2004) provides a foundational premise behind the emergence of socio-technical innovations in the construction sector. According to Rohracher (2001), institutions and socio-technical characteristics in the construction sector may either support or hinder potential of business renewal towards more sustainable building structures. As observed by Hemström *et al.* (2017), strong cognitive rules within the construction sector are founded within the concrete-based building culture, which focuses on cost considerations and perceived performance, and to a lesser degree on customer preferences. Competition between new players entering the industrial construction market, and collaboration between WMC and traditional (concrete-driven) construction businesses, are the key elements that require more in-depth analysis (Hemström *et al.* 2017).

To gain better understanding of the forces shaping the future of WMC, we will empirically focus on the institutional context of two Nordic countries (Finland and Sweden), where national bioeconomy strategies explicitly mention the objective of enhancing wood utilization in construction. Based on Kadefors (1995), we hypothesize that the barriers obstructing the market diffusion of the WMC are to some degree related to the institutional setting from which innovations, mutual learning and co-operative ways of creating value in a business environment emerge. Our research question is: which internal and external factors of competitiveness shape the future of WMC? Methodologically we use a three-stage dissensus-based Delphi approach to analyse the changing WMC business environment.

## Theoretical framework

### *MLP and the role of institutions in shaping the future of the WMC business system*

From the perspective of understanding the innovation potential related to the future construction business in the European context, cross-cutting changes have been identified to deal with the shift from products to systems and services, blurring sectoral boundaries and cross-sectoral integration of sustainability demands (Weber and Schaper-Rinkel 2017). The competitiveness (i.e. superior performance within an industry assessed with chosen measures) and renewal of companies in the construction sector have traditionally been affected by the strategic decisions made by firms, public authorities (e.g. regulation and public procurement initiatives), and professional bodies and trade associations (e.g. standardization and education) (Porter 1985, Betts and Ofori 1994, Lähtinen and Toppinen 2008). Similarly, linkages comprising company strategies, interactions between various construction sector actors, and the external business environment have been found to affect the future prospects of WMC sector (Mahapatra and Gustavsson 2008, Hemström *et al.* 2017).

According to institutional theories, organizations are affected by normative pressures, which leads them to adopt similar behavioural patterns to create efficiency benefits (DiMaggio and Powell 1983, Zucker 1987). Formal institutions also tend to create lock-ins and hinder changes that might positively affect industry dynamics, for example, through innovation diffusion (Eriksson 2013). Based on theoretical assumptions made by the MLP on socio-technical transitions approach, three levels of processes affect the transformation of technologies and innovations: niche innovations, the socio-technical regime and the socio-technical landscape (Geels 2002). As the socio-technical landscape level is an exogenous environment (e.g. deep cultural structures and macro-politics taking decades to form) (Geels and Schot 2007), niche level and the socio-technical regime level are the focus of our study. According to Fuenfschilling and Truffer (2014), niche innovations represent alternative socio-

technical configurations in MLP, which do not have a high level of institutionalization. They are composed of small and unstable communities of interacting groups (e.g. actors entering and leaving, markets, technical standards not being developed, or unknown user preferences) (Geels 2002, 2004). As a comparison, regime level communities are large and stable (e.g. deviating from mainstream practices is difficult, markets are developed, technological standards exist, and actors in business networks have aligned their processes with each other).

In the construction sector, the roles and tasks of various actors have become highly routinized and standardized over the course of time to manage the complexity of construction processes (Kadefors 1995, Segerstedt and Olofsson 2010). Due to the established behavioral patterns, changing the dynamics of the construction sector is not straightforward (Rohracher 2001): First, changing from niche level into socio-technical regime requires comprehension of how incumbent actors in the construction sector interact with each other and what are their strategic interests. Second, information is needed on how different actors are shaping intentionally or unintentionally the institutional structures in the sector. As a solution to recognize the inseparability of technical and socio-technical aspects in construction business, Rohracher (2001) has illustrated the dynamic interaction between technologies, institutions and interaction of actors in the industry. Construction sector actors are composed of individual organizations involved in the WMC business (i.e. firms, governmental agencies, industry and professional associations, interest organizations, R&D organizations and educational organizations). Following the approach illustrated in Figure 1, our analysis is conducted through the MLP on socio-technical transitions approach (e.g. Geels 2004, Geels and Schot 2007, see also Bosman and Rotmans 2016), complemented with the lens of institutional theories (e.g. Meyer and Rowan 1977, DiMaggio and Powell 1983, Scott 2008, Beckert 2010).

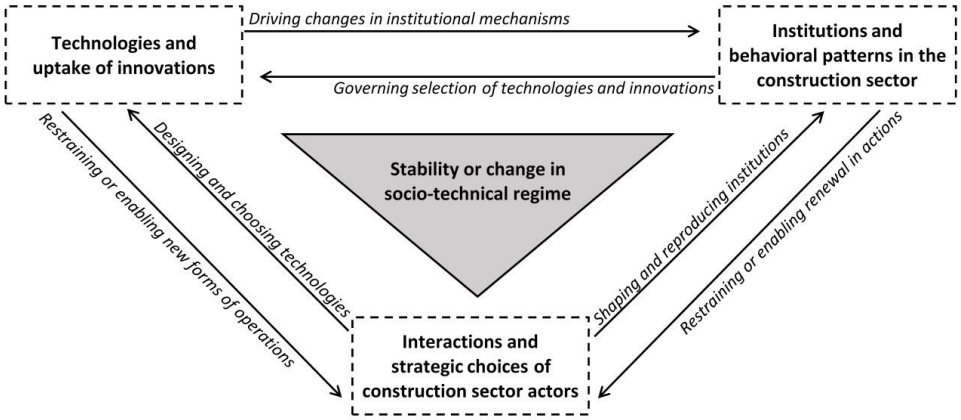



**Figure 1.** Dynamics between technologies, construction sector actors and institutions affecting the market diffusion of WMC from niche innovation to regime level (modified from Rohracher, 2001).

In our study, technologies and uptake of innovations comprise various solutions to implement WMC. From the perspective of MLP, WMC may have mixed effects, for example, on other building technologies by supporting certain ones and by provoking major crises in others (see Dolata 2009). Formal institutions comprise behavioral patterns formed over time resulting from path dependencies to control either internal or external factors affecting both technologies and actors. Dynamics between technologies, institutions and interactions between actors may therefore either limit or enhance the competitiveness of WMC in the markets and its potential to develop from niche level into socio-technical regime level (Rohracher 2001, Dolata 2009).

### *Construction sector as a business system*

Construction sector is characterized by project-based and subcontracted businesses (Segerstedt and Olofsson 2010), which requires a good fit and coordination between interdependent and non-simultaneous tasks implemented within strict timelines (Blayse and Manley 2004). Due to this, business networks and their ways of organizing project-based business processes are of fundamental importance in construction sector operations (Gann and Salter 2000), for example, by providing access to complementary resources and innovation platforms (Pulkka *et al.* 2016). In the construction

sector, the uptake of new building solutions has been found to be challenging despite their perceived benefits (e.g., Carter 1967, Holt 2013). Traditions and patterns of behavior in the construction sector operations are also key factors likely to affect WMC market diffusion (Nordin *et al.* 2010). In a recent study by Matinaro and Liu (2017), traditional organizational culture was found to be a key aspect hindering innovativeness and sustainability in the Finnish construction sector.

The organization of business networks in the construction sector usually targets a particular project and is composed of firms managing the actual building processes (e.g. on-site contractors and client service providers such as consultants) and supplying, for example, the materials and machinery for the contractors (Gann and Salter 2000, Nordin *et al.* 2010). Thus, the coalitions in the construction sector are characterized by temporariness (Blayse and Manley 2004), which results in a lack of mechanisms for transferring experiences from individual projects to company-level decision-making, and causes challenges, for example, for continuous learning (Drejer and Vinding 2006).

Figure 2 is a theoretical illustration of the internal factors of project-based business networks, and the external factors of regulatory framework and technical infrastructure, both affecting the innovation potential and competitiveness of individual companies within the WMC business system. According to management literature, examples of internal factors include resources and processes in the control of individual companies and/or business networks (e.g. Barney 1986; Helfat and Martin 2015), while external factors are either entirely or largely outside of their control (e.g. Elenkov 1997; Acur *et al.* 2012). Both internal and external factors affect the competitiveness of companies (e.g. Mauri and Michaels 1998 Hawawini *et al.* 2003), as also found to be the case in the woodworking industries (Lähtinen 2007) and construction sector (Holt 2013). In our study, we propose that these internal and external factors, managed through different formal institutions within the construction sector business environment, affect the future competitiveness of the WMC business, in line with Nordin *et al.* (2010).

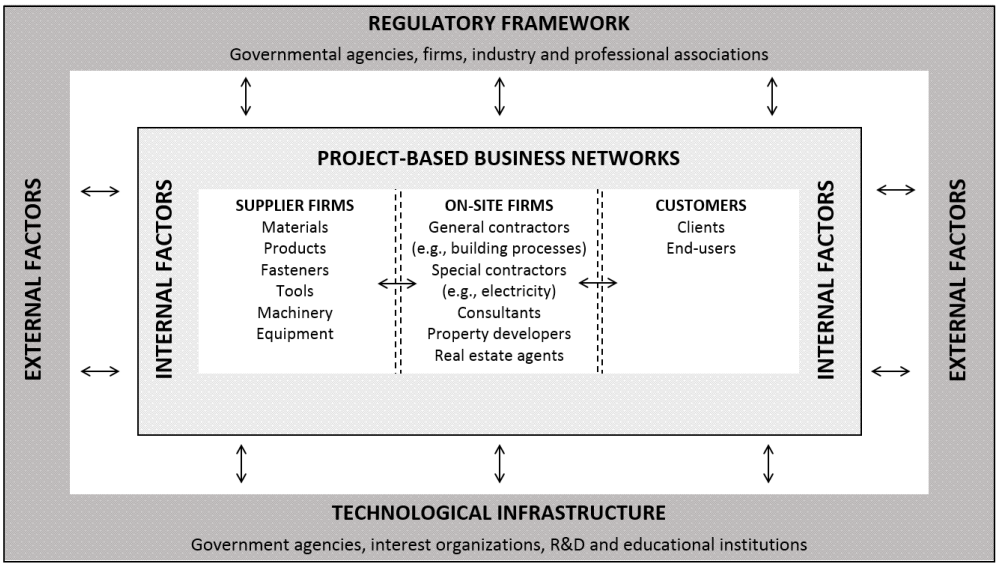



**Figure 2.** Internal factors (i.e. actions made by actors within project-based business networks) in relation to external factors (i.e. actions made in regulatory framework and technical infrastructure) affecting the competitiveness of the WMC business system (modified from Gann and Salter 2000).

In business networks of a particular sector, the adoption of "institutionalized" best practices and standards enhances the management of value chain activities and further the competitiveness of companies (see e.g. Ketchen and Hult 2007). From the perspective of expected benefits, although aspects of institutionalization, such as routines and efficient labour use, have improved the cost-competitiveness of construction companies, project-based structures and strong cultural traditions within the sector have simultaneously hindered the diffusion of innovations such as finding new building solutions from engineered wood products for multistorey timber construction (Kadefors 1995). In line with management literature (e.g. Barney 1986; Helfat and Martin 2015), from the perspective of the WMC business system, project-based business networks (i.e. internal factors) control the development of learning and routines between various projects, the uptake of new "best practices" and the search for optimal combinations through bidding processes. In comparison, project-based business actors do not authorize e.g. the defining of building permit procedures, the

facilitation of knowledge diffusion throughout the construction sector or assuring the compatibility of various technologies (i.e. external factors).

Construction sector is characterized by several formal and informal institutions affecting the competitiveness of companies abreast with their selection of technologies and interaction with other actors operating in the sector. According to Kadefors (1995), there are six types of institutions in the construction sector (illustrated in Table 1) affecting the transformation potential of the construction sector towards new socio-technical regime either through actions made within project-based business networks (internal factors), or in regulatory framework or technical infrastructure (external factors) (see also Figure 2).

**Table 1.** The six types of institutions in the construction sector defined by Kadefors (1995) as the actors controlling internal and external factors in the WMC business system.

| INSTITUTION* | POSITION IN THE WMC BUSINESS SYSTEM | PURPOSE OF THE INSTITUTION WITHIN THE WMC BUSINESS SYSTEM |
|---|---|---|
| 1. Learning and routines | Project-based business networks (Control of internal factors) | To develop social patterns, practices and processes that support the dissemination of information and knowledge diffusion between separate projects, also enhancing the uptake of new routines and process innovation capabilities as, for example, customer needs become more diverse (Bresnen 2003). |
| 2. Standardization of skills and knowledge | Project-based business networks (Control of internal factors) | To enhance capabilities for re-engineering construction processes and defining new "best practices" without compromising efficient and error-free project implementation (Roy *et al.* 2005). |
| 3. Tendering system | Project-based business networks (Control of internal factors) | To find an optimal combination of, for example, suppliers for a given construction project by using bidding processes (e.g. Hatush and Skitmore 1997). |
| 4. Governmental regulations | Regulatory framework (Control of external factors) | To ensure that good practices are being followed in building permit procedures, building supervision, technical solutions and building usage (e.g. The Land Use and Building Act (132/1999)) |
| 5. Roles and interest organizations | Regulatory framework (Control of external factors) | To facilitate knowledge diffusion throughout the construction sector and provision of normative directions for member companies and other organizations, for example, through negotiations and lobbying (Vermeulen *et al.* 2007) |
| 6. Formal standardization initiated by the industry | Technological infrastructure (Control of external factors) | To assure that components and technologies are applicable with each other independently from selected suppliers in the bidding processes (Dubois and Gadde 2002) |

**Defined as "rule" in MLP (see Geels and Schot 2007).*

**Data and Methodology**

We use Delphi methodology to qualitatively analyse a wide variety of problems in the emerging WMC domain, and the reliability and validity of our research results is strengthened through general verification strategies (Morse *et al.* 2002). These strategies comprise aspects of methodological coherence (suitability of the method to answer the research questions), sample appropriateness (selection of the experts), concurrent collection and analysis of the data, theoretical thinking (employment of solid theoretical background) and theoretical development (purposeful seeking of linkages concerning the results on new theoretical findings).

Iteration, participant and response anonymity, controlled feedback and statistical group response have been identified as key characteristics of a Delphi study. During its 50-year existence, numerous variants of the methodology have been developed (Landeta 2006), with the later ones (e.g. Policy Delphi, Argument Delphi and Disaggregative Policy Delphi) emphasizing the importance of finding reasons for dissensus rather than striving for consensus among experts (Blind *et al.* 2001, Hatcher and Colton 2007, Landeta 2006, Rowe and Wright 1999). Typically, bringing (geographically) dispersed experts together and sharing a personal viewpoint without group pressure due to anonymity are seen as advantages of utilizing the Delphi method. On the other hand, a lack of strict guidelines on how to implement a Delphi study and low participant commitment can be considered challenges or disadvantages of the method (e.g. Hung *et al.* 2008; Gupta and Clarke 1996).

The methodological approach of our study is drawn from a three-round dissensus-based Delphi study, which provides opportunities for recognizing important and interesting issues and possible cognitive biases outside the evident consensus (Rowe and Wright 2011). Dissensus approach is reasonable, when the main purpose of the study is to explore little understood, not well documented phenomena (Steinert 2009), as in this case.

As the Delphi method is suitable for implementing explorative research, we chose to utilize it in this study: answering our research question requires achieving information concerning future aspects of the factors shaping the WMC business development, with no existing empirical data available on the topic. Therefore, we expected a variety of possible futures for WMC and factors affecting its competitiveness. To map these possible developments, we aimed to collect as rich a dataset on the views and opinions of experts as possible. Instead, the purpose was to also recognize possible weak signals and alternative voices. Therefore, to have genuinely new information concerning the renewal of the WMC business, the dissensus-based (in contrast to consensus seeking) Delphi was seen to fulfill both the empirical and theoretical objectives of our study (see e.g. von der Gracht 2012; Steinert 2009). We thus believe that it would not be possible to gain sufficient in-depth understanding of the future of the WMC without performing multiple interview rounds, especially from the viewpoint of such a multifaceted measure as competitiveness.

The number of Delphi panellists typically ranges from a few to 50, (also in the area of construction engineering and management, see Hallowell and Gambatese 2010). However, the key criterion in selecting the panel is the members' expertise and contribution to the topic. In our study, the panellists involved were of Finnish and Swedish origin, and were required to have in-depth knowledge of wood utilization in multistorey construction in the Nordic region. To collect data that would provide an all-inclusive view, we proceeded to find experts representing various parts of the WMC value chain. Therefore, we broke the WMC value chain into (1) forest resource ownership and raw material procurement, (2) wood products industry and primary processing and (3) construction industry, and searched for experts to represent these segments.

We searched for possible panellists based on publicly available information on employees who represented companies or formal institutions suitable for our sample frame, along with their expertise, and enquired about the candidates' willingness to join the panel. Panel composition was not revealed

to the panellists at any point to minimize any bias that the group or group members could cause to the panellists' opinions (e.g. dominant expert influence, persuasive skills, unwillingness to reveal a change in previously expressed opinion; see e.g. Steinert 2009, von der Gracht 2012). We collected data from a panel of 23 experts using dissensus-based Delphi during 2016–17 to elicit perceptions on the future pathways and sources of competitiveness in WMC in the Nordic region (see Table 2).

**Table 2.** Composition of the Delphi panel with their professional backgrounds and participation in various stages of data collection.

| Country | Gender | Years of professional experience | Title | Organization type | Participation in rounds |
|---|---|---|---|---|---|
| Finland | Female | 1 | Executive | Building industry | 1–3 |
| Finland | Male | 12 | Technical manager | Building industry | 3 |
| Finland | Female | 16 | Planning executive | Building Industry | 1–3 |
| Finland | Male | 26 | Production director | Building industry | 1–3 |
| Finland | Male | 3 | Field manager | Forestry | 1–3 |
| Finland | Male | 15 | Research manager | Forestry | 1–3 |
| Finland | Male | 16 | Owner | Forestry | 1, 2 |
| Finland | Male | 31 | Managing director | Forestry | 1–3 |
| Finland | Male | 15 | Senior advisor | Public sector | 3 |
| Finland | Male | 23 | Managing director | Wood ind. Association | 1, 3 |
| Finland | Male | 5 | Senior vice president | Wood industry | 1, 2 |
| Finland | Male | 14 | Senior vice president | Wood industry | 1–3 |
| Finland | Female | 22 | Director of CSR | Wood industry | 1, 2 |
| Finland | Male | 22 | Sales executive | Wood industry | 1–3 |
| Sweden | Male | 12 | Academic expert | Building ind. Expert | 1–3 |
| Sweden | Male | 15 | Academic expert | Building ind. Expert | 3 |
| Sweden | Male | 17 | Vice pres. market dev. | Forestry | 1, 2 |
| Sweden | Male | 21 | Senior advisor | Forestry | 1, 2 |
| Sweden | Female | 10 | Managing director | Public sector | 3 |
| Sweden | Male | 8 | Sales manager | Wood industry | 1, 2 |
| Sweden | Male | 11 | Managing director | Wood industry | 2, 3 |
| Sweden | Male | 11 | President | Wood industry | 1 |
| Sweden | Male | 15 | Managing director | Wood industry | 1–3 |

A total of 18 experts were interviewed during the first round, 17 responded to our second-round online survey, and finally 16 experts were interviewed during the third round. Nineteen of the 23 experts

had over ten years of experience from either the forestry, wood industry or construction sectors. All panellists acted in high-level leadership or professional expertise positions, which we believe improves the internal validity of our results.

The time scale of our Delphi approach was extended towards 2030 and the study consisted of a content analysis of the data collected during two thematic interviews (rounds 1 and 3) and a structured online survey (round 2). We chose to begin data collection with the interviews, as this enabled asking follow-up questions or asking interviewees to further elaborate on their responses, if needed. Abreast with strengthening the validity of our study by ensuring that all respondents had understood the questions in a similar manner, this approach allowed us to map as large a variety of opinions as possible at the beginning, which is a good base for the dissensus-based approach.

Data collection is iterative in the Delphi process, and therefore the data from the first and second rounds was summarized, and controlled feedback was provided to the panellists always prior to beginning the next data collection phase (von der Gracht 2012). After the third round (interviews), despite marginal new information emerging, many issues began repeating in the panellists' answers. Based on this, we concluded that the information value gained from additional rounds would likely be small, and the data collection process was stopped.

The first-round interviews concerned general issues occurring in the business environment of WMC business systems such as initiatives related to sustainable development, the overall state of the forest industries, raw material supply and end-use markets. Abreast with these themes, questions related to existing patterns, such as the behaviour of individual organizations, characteristics of collaboration in value chains, structures in WMC business systems and institutions for acquiring information on the position of WMC in niche and socio-technical regimes were asked from the panellists. During the second Delphi round, emphasis was given to the themes and topics considered the most thought-

provoking or controversial during the first phase. The questionnaire mainly consisted of closed-ended questions in the form of 42 statements (some of which have already been reported in Toppinen et al. (2018), and are therefore excluded from here), and respondents were given five response options ranging from very low, neutral to very high. The third-round interviews were needed to prioritize the most important internal and external factors influencing WMC competitiveness, and to open up underlying rationale that remained unclear after the first two rounds.

In the situation of mainly open-ended questions, we considered that the probability to get sufficient information is greater by using interviews as compared to a questionnaire, since it is easier for the informant to more freely speak than write, and also with scheduled interviews we could ensure that the participation rate did not decrease. More importantly, in the interactive situation both the informant and the researcher have a possibility to check in case of any obscurity. We found this important, since the third round (based on the first two rounds) was likely to be the last round, but also because of the purpose of the data collection was (not to find specific points of consensus but) find weak signals and alternative voices.

There are limitations in Delphi technique and throughout the years, the method has faced a lot of criticism (e.g., Hung et al., 2008). Winkler and Moser (2016) identified the most frequent and impactful cognitive biases in Delphi studies to be *framing bias* (i.e., how the issue is presented or modified has influence on the person's assessment of the issue), *anchoring bias* (i.e., estimation of a value for a variable referring to a known previous value), *desirability bias* (i.e., the informant's stance towards the events desirability may influence on the judgement of the likeliness of an event to take place), and *bandwagon effect* (i.e., influence of the behavior of group or the majority to the informant's behavior or opinion, that bases on the information that the majority behaves or thinks in certain way), and *belief perseverance* (i.e., the decision maker's aptitude – when receiving a

unconfirmatory advice – to overweight their own judgmental performance and underweight the advice available).

Winkler and Moser (2016) presented a list of recommendations for the design of Delphi study to avoid these biases; the most important recommendation considers the panel, namely the authors conclude that the panel should be heterogeneous, include mavericks and that pyramid search should not be applied when choosing the panellists. In this study we have attempted to reach heterogeneity of panel composition in terms of gender, years of experience, organizational position, and type or industry, however, the degree of reached heterogeneity is somewhat subjective issue. The panellists were chosen based on public information, and we did not use pyramid search.

While in our study we have attempted to follow the recommendations considering Delphi studies, particularly in terms of carefully choosing the panellists, retaining their anonymity and producing feedback between rounds, the possibility of some degree of bias remains. This should be considered when interpreting the results of this study.

## Results

### *Wood as a future construction material*

The interviewed Delphi panellists from both Finland and Sweden were fairly confident that wood utilization would increase in the future as a more modern and sustainable building solution in the construction sector. Multistorey buildings were the most commonly mentioned modern construction solution, but certain respondents also identified infrastructural constructions, such as wooden bridges, to be a growing segment for the WMC business. Two respondents mentioned that engineered wood products (EWPs), such as cross-laminated timber (CLT), will open new possibilities for utilizing wood in load-bearing structures, elements or as a substitute for concrete. Hybrid buildings made of wood combined with other materials, such as concrete and steel, were also mentioned in this

discussion as a new opportunity to increase wood usage in the construction sector. Regarding the connections between uptake of new technologies and interactions illustrated in our theoretical framework of Figure 1, this is a signal of the potential of WMC to act as a driver for increasing new forms of collaboration among actors, which traditionally have not co-operated with each other.

However, a lack of positive examples and experience of WMC as a dominant building technology and material choice was seen as a persistent problem, as indicated by one interviewee: "*No major issues exist that we could not tackle, we just happen to be at a very early stage.*" ***Wood industry executive, Finland.*** In reference to our theoretical framework, this indicates that WMC is occurring at the niche level. Deficiencies appear to exist within the institutions connected to internal factors of the WMC business systems (i.e. "Development related to the formation of new learning" and "Routines within business networks"), limiting the potential for developing and implementing new building solutions. Some respondents challenged the increasing collaboration between the wood construction sector and concrete solution providers due to obstacles, such as the nonexistence of similar optimum dimensions for construction materials and structures, and because of the on-going public 'wood vs. concrete' antagonism. In relation to collaboration and innovation activities with concrete building companies, WMC building does not seem to be even at the niche level. This claim is supported by the institutional weakness referring to development efforts in common technological standards and the alignment of business processes (i.e. "Formal standardization initiated by the industry"). One respondent summarized the situation in the following way: *"I don't think co-operation [with the concrete business] will happen – there is just too much competition"* ***Wood industry executive, Sweden.***

Key challenges facing deepening collaboration cited by the experts included differing timespans in which the actors of business networks operate and the new capabilities that various organizations have to develop for enhancing the market diffusions of WMC building solutions. From a theoretical

viewpoint, this refers to the need of niche-level factor development in formal institutions related to internal factors of WMC business systems (i.e. “Standardization of skills and knowledge” and “Learning and routines”). Systematic development of knowhow is needed when implementing new building solutions within companies, to e.g. re-structure construction processes and enhance the uptake of new process innovation capabilities (see Table 1).

Respondents also identified project length to be a timespan issue, as the following illustrates: “*[Building] processes can be very long, even unbearably so.”* ***Research manager from a forestry expert organization, Finland.*** The development of more sophisticated building solutions was seen as a capital-demanding process for which only a few of the largest operators have the necessary resources. Building contractors, especially ones that build with a range of materials, were not interested in developing solutions, and are actually only interested in bringing solutions to the markets. This is further illustrated by the following quote: “*We will not perform this validation [of wood-based building solutions], which needs to be undertaken by the wood industry itself.”* ***Building company executive, Finland.*** Based on this, on-site firms, such as general contractors, are willing to enhance WMC innovation diffusion. But, prior to that, in reference to our theoretical framework, WMC business systems need to pay attention to re-structuring both the internal and external factors affecting their operations *via* various informal institutions (i.e. “Formal standardization initiated by the industry”, “Roles and interest organizations”, “Standardization of skills and knowledge”). In practice, this means e.g. more profound collaboration with on-site contractors to enhance innovation diffusion towards a socio-technical regime, standardized products technologically applicable with other materials along with the development of routines and skills that go beyond individual construction projects creating positive path dependencies and reshaping informal institutions in the course of time.

***Internal and external factors driving competitiveness of the WMC***

Competitiveness of the wood construction industry has been discussed in-depth within the industry, which also became evident during the first round of interviews, as the following quote shows: *"Everyone needs to take care of their own competitiveness, it is very challenging to play in every field... I believe in network thinking, in which various actors co-operate by leveraging their own strengths."* ***Wood industry executive, Finland.*** Theoretically, this refers to the need of a well-functioning division of work and institutional WMC business system specialization in reference to internal factors, such as knowledge development and the identification of best practices within collaboration networks, to secure efficient processes and good quality project implementation (i.e."Standardization of skills and knowledge).

A respondent in one interview explicitly stated that he sees the industry as going through a paradigm shift, and other experts similarly talked about an on-going change that they saw taking place in their institutional and business environment. Therefore, in the next two rounds, we focused on more explicitly mapping expert perceptions of what the external and internal factors and institutional changes are that impact the competitiveness of the industry. Table 3 presents the likelihood and desirability of the second-round statements concerning the competitiveness and development of the industry. Please note that the original five-point statement scaling has been clumped into three categories (low, neutral and high) to simplify presentation in Tables 3 and 4.

**Table 3.** Percentages of likelihood and desirability of round two statements concerning the competiveness and development of the industry by 2030 (n=17).

| STATEMENT | LIKELIHOOD (%) | | | DESIRABILITY (%) | | |
|---|---|---|---|---|---|---|
| | Low | Neutral | High | Low | Neutral | High |
| *By 2030, the overall product offering of the wood product industries will offer a significantly more diverse range of wood products than today.* | 6 | 12 | **82** | 6 | 6 | **88** |
| *By 2030, wood product industries will offer significantly more value-added products than today.* | 0 | 29 | **71** | 0 | 12 | **88** |
| *Wood product industries are going through a paradigm shift, and will operate in a completely new way by 2030.* | 6 | 35 | **59** | 0 | 24 | **76** |

| | | | | | | |
|---|---|---|---|---|---|---|
| *By 2030, the wood construction industry will still struggle with competitiveness and lack of value-added products.* | **41** | 24 | 35 | **59** | 29 | 12 |
| *By 2030, large-scale wooden construction, such as wooden multistorey building projects, has become the most important segment within wood construction.* | 12 | 29 | **59** | 0 | 29 | **71** |
| *By 2030, the flow of information from the construction site to the forests will be significantly faster.* | 0 | 18 | **82** | 8 | 18 | **82** |
| *By 2030, consumers will see wood construction as a modern way of building.* | 0 | 12 | **88** | 0 | 6 | **94** |

The majority of the panellists considered statement *2030, the overall product offering of the wood product industries is significantly more diverse than today",* to be both highly likely and desirable. Respondents also believed that the wood product industries will offer more value-added products by 2030. However, a great deal of uncertainty appears to exist when compared to certain other statements concerning this issue: for example, statement "*By 2030, the wood construction industry will still struggle with competitiveness and lack of value-added products*" was seen as undesirable by more than half of respondents (59%), which is a logical outcome. Certain respondents believe it likely that issues with competitiveness and a lack of value-added products will still exist in 2030 (35%), others are neutral in their views (24%), and certain respondents do not consider this at all likely (41%). Based on this, we concluded that the topic deserved further attention in the final (third) interview round.

Regarding changes at both the niche and socio-technological regime levels, experts considered it desirable that WMC business systems will operate in a completely new way by 2030, but 59% of the panellists assessed the likelihood of this happening to be moderate. The panellists were more positive about how consumers will view the industry in 2030 compared to how wood construction is regarded as a modern way of building: 88% of the panellists believed this development highly likely and 94% considered it desirable. When the panellists were asked about the role of the multistorey building segment within wood construction business, the majority believed it becoming a dominant field to be both likely (59%) and desirable (71%). Also, information flow from the construction site to the forests was believed to become more rapid in the future. Thus, compared with our theoretical framework,

panellists were more optimistic towards issues directly unrelated to internal and external factors of WMC business systems as such (e.g. consumer attitudes or the role of WMC within the wood construction sector). Instead, they were having a weaker trust in drastic changes occurring within actual WMC business systems that would allow them to become large, stable and coherent at socio-technical regime level.

Table 4 summarizes the likelihood and desirability of the second-round statements related to the use of wood as a building material in the future. Eighty-two per cent of the panellists considered wood becoming a competitive building material by 2030 to be highly desirable, and 65% viewed this to be highly likely. When panellists were asked about the competition for wood as a building material, 47% were neutral in their views, whereas 41% believe that increasingly intense competition over the raw material is highly probable. Furthermore, panellists did not consider it likely that the cost of wood-based materials would represent a significantly larger proportion of the overall costs of WMC by 2030.

Statement "*By 2030, it will be possible to make more value-added products from lower quality raw materials due to technological development"* continued on from a perspective raised by previous literature, but to which respondents had differing opinions in the interviews. During the first-round interviews, several panellists argued that technological development in the future will enable actors in the wood construction business to manufacture value-added products from lower quality raw materials. During round two, this development was considered both highly likely (88%) and desirable (82%). Finally, experts anticipate that in the future, builders will be more educated in terms of available materials and hybrid solutions.

**Table 4.** Percentages of likelihood and desirability of round two statements concerning wood as a raw material by 2030 (n=17).

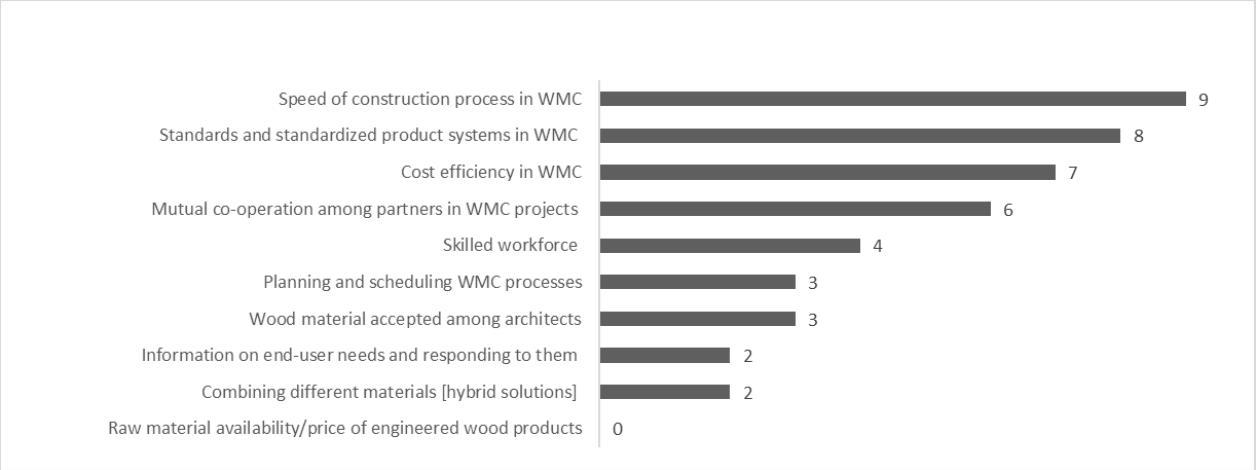
| STATEMENT | LIKELIHOOD (%) | | | DESIRABILITY (%) | | |
|---|---|---|---|---|---|---|
| | **Low** | **Neutral** | **High** | **Low** | **Neutral** | **High** |
| *By 2030, wood has become a competitive construction material in its own right* | 0 | 35 | **65** | 0 | 18 | **82** |
| *By 2030, new wood-based products (for example advanced biomaterials made of wood) will create significantly more competition over raw materials* | 12 | **47** | 41 | 24 | **47** | 29 |
| *By 2030, the cost of raw materials will be a significantly larger proportion of the overall costs of wood construction.* | 12 | **71** | 18 | 18 | **71** | 12 |
| *By 2030, it will be possible to make more value-added products from lower quality raw materials due to technological development.* | 0 | 12 | **88** | 0 | 18 | **82** |
| *By 2030, builders will be significantly more educated about all available materials and hybrid solutions.* | 0 | 12 | **88** | 0 | 6 | **94** |

In sum, the panellists appear to be highly like-minded in believing that the wood industry will be more diversified by 2030, and that due to technological development, more value-added products made from lower quality raw materials will be available on the market. However, some scepticism remained, especially on whether the industry will still struggle with competitiveness. Experts do not fully appear to believe in the transformative power of building regulations and emerging business opportunities in WMC. Therefore, we investigated reasons for this in the next Delphi-round using interviews to enable more in-depth insights (von der Gracht 2012).

In Delphi round three, panellists were asked about the most important internal and external factors influencing WMC competitiveness. Based on the previous rounds, panellists were provided with a list of ten internal and external factors, and were asked to name three of the most important items from the external and internal viewpoints, or to define additional factors if they considered something to be missing from the provided list. Figures 3 and 4 show the panellists' answers and how frequently the provided option was chosen as one of the three most highly ranked factors. Please note that only 16 experts responded to this question, and every panelist did not rate three factors, thus giving us only 45 votes.

Construction process speed (nine times) and standardization (eight times) were the internal factors chosen most often by the panelists (Figure 3). These responses signal the need for decreasing costs, and thus improving cost-competitiveness. Increased speed and standardization would also increase end-user value. Plain cost-efficiency was the third most chosen option (seven times). The speed of the construction process may partly be a question of being at the early stage of the learning curve. As one of the expert comments: *"Repetition [of multistorey building projects] will bring speed. So far no wooden multistorey building [project] has completely succeeded."* Accumulating experience and learning will speed up the process and decrease costs up to a certain point. Naturally, the risk is that if the disadvantageous cost competition situation slows down the diffusion of WMC processes, it will take longer for the industry to reach (or prohibit the industry from reaching) the positive learning effects.

**Figure 3.** Frequency of perceived importance of internal factors influencing competitiveness. Sixteen respondents of round three were asked to name three of the most important items from the internal viewpoint and to justify their choices.

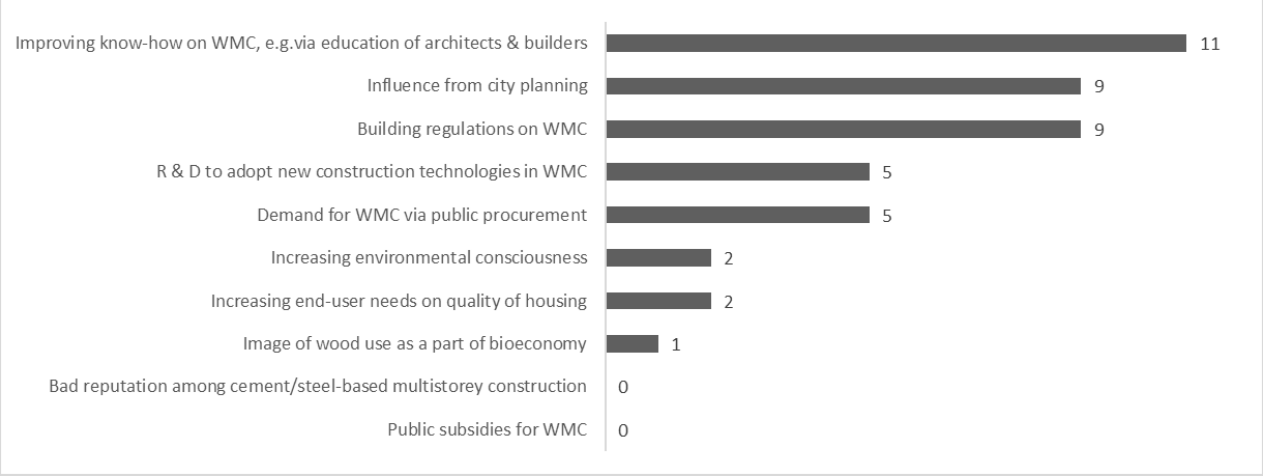



In line with the two previous Delphi rounds, here too respondents do not consider raw material issues as the most important factor. In light of the answers concerning the development of the industry by 2030 (especially the positive view regarding the diversity of overall product offerings and value-added products), it is interesting that only two respondents believe combining different materials in

hybrid structures to be one of the three most important issues. Responses to the latter question may have been given with the current situation in mind, while the question in round two was considered from a more future-oriented viewpoint. On the other hand, from the innovativeness point of view, the new value-added products will not be realized if the industry lacks the willingness or capability to look outside of the box. In our case, development of hybrid construction solutions represents a natural avenue for gaining higher functional benefits, e.g. by taking advantage of technological properties of different materials.

In terms of influential external factors (see Figure 4), nearly 70% of respondents ranked "*Improving WMC know-how,* for example, via the education of architects and builders" as one of the three most important external factors. "Influence from city planning" and "Building regulations concerning WMC" were both chosen nine times.

**Figure 4. Frequency of perceived importance of external factors influencing competitiveness.** Sixteen respondents in round three were asked to name three of the most important items from the external viewpoint and to justify their choices.




Among the provided alternatives, "public subsidies" was not considered important, but "demand for WMC via public procurement" and "R&D to adopt new construction technologies in WMC" were both chosen five times. Thus, the bulk of the answers points towards issues that can be directed by

means of regulatory framework. Only one expert considered the "image of wood as part of the bioeconomy" as one of the most important factors, and two believed "housing quality needs" to be the most important factor. The demand side appears less important in the answers, which may be due to question design. This could portray the similar attitude by one of the experts, who commented: "*End-users are not important. Municipalities are*".

**Discussion**

In our study, we approached the future of WMC business in Finland from the viewpoint of our research question aiming to identify factors shaping the future competitiveness of WMC. By using additional insights available from Sweden, we were able to envisage WMC development to that in construction markets also in more general. From the perspective of institutions (see Figure 2 and Table 1), both external factors related to regulatory framework and technical infrastructure, and internal factors of business networks were operationalized in the expert views as issues affecting the future of WMC. From the perspective of theoretical interlinkages between MLP and institutions affecting the future of WMC, our empirical results supported the assumption of three-dimensional dynamics (i.e., technologies, institutions and interactions between actors) shaping the potential of WMC to move from a niche innovation into socio-technical regime level.

According to our results, the importance of educating architects and builders gained highest support among the panellists. In comparing with Table 1, the views emphasized most by the experts fell within the external factor category of "Formal standardization initiated by the industry" and within the internal factor categories of "Standardization of skills and knowledge" and "Learning and routines". Thus, although "Governmental regulation" (external) and "Roles and interest organizations" (external) were also mentioned by the experts as factors impacting the future of WMC, they were less interesting to the respondents. In addition, although "Tendering system" is currently the dominant

routine for organizing work in construction projects, it was not directly approached during the third-round expert interviews.

The purpose of the "Formal standardization initiated by the industry" and the applicability of the construction components independently from suppliers enhances, for example, efficiency and cost-competitiveness (e.g. Dubois and Gadde 2002). From the regulatory framework perspective, industry standardization is a non-legislative approach for implementing guiding norms, for example, for a particular industry. According to our results, the Delphi experts did not believe builders to be interested in developing standardized wood construction systems, and wood industry was seen as a key player in the standardization work. Abreast with cost-competitiveness, standardization based on new material based solutions (such as cross-laminated timber elements) was seen as an opportunity to substitute concrete in construction processes.

As an internal factor of competitiveness, "Standardization of skills and knowledge" was similar to "Formal standardization initiated by the industry", but instead of formal instructions received from outside the project-based business networks, skills and knowledge were seen to be connected with developing capabilities that enable companies to re-engineer their construction processes (e.g. Roy *et al.* 2005, Roos *et al.* 2010). Furthermore, our Delphi experts considered skills and knowledge development highly crucial for learning, developing the division of work, and for allowing the partners to focus on their specific strengths within the larger business network. This could be a relevant issue especially in case of developing more advanced hybrid material based construction solutions.

"Learning and routines" within the construction industry is related to issues of developing new social patterns, practices and processes that may enhance innovation diffusion (Bresnen 2003, Roos et al. 2010). In WMC business networks, the need for "being innovative when developing new building

solutions" was emphasized, for example, to increase the speed of WMC building projects. Abreast with this, fierce competition between wood and concrete construction affects the future development potential of the entire construction sector, and business renewal experiences, challenges in finding optimal component dimensions to consolidate the products and processes of WMC and concrete companies. Essentially, these are the main issues affecting the possibilities of developing competitive hybrid building solutions.

Regarding "Learning and routines", potential benefits exist for the WMC and concrete companies in hybrid building, if new social patterns would develop between the business networks of these industries (Wang *et al.* 2014). As a result of social linkages, the potential of finding innovative component dimension solutions, enabling a better fit between WMC and concrete products, could also be developed. For example, challenges related to co-operation between the actors and the long timespans of the construction projects were identified as problems during the first Delphi round, and further inquiry into the matter confirmed these to be critical issues. Possibilities exist, for example, in building new cross-sectoral collaboration relationships between actors from wood industry and construction industry, and by moving away from the cost efficiency-centered mindset towards stronger customer orientation, as also emphasized in the previous literature (Bygballe and Ingemansson 2014, Matinaro and Liu 2017).

Our results are in line with Hemström *et al.* (2017) for Sweden, which found that the strong cognitive rules in construction are founded in the concrete-based building culture. Although this feature is likely to also inhibit the dynamics of the socio-technical regime towards 2030, there are also signals that the dynamics in the form of more frequent interactions between actors (e.g., business collaboration between wood and concrete driven companies) and the related technological development (e.g., development of hybrid building solutions) could evolve. The institutional structures may also be a

source of change. Our panellists voiced that the WMC at the niche level could represents the key channel of future change towards a greener construction sector.

According to Toppinen et al. (2018), there appears to be a lot of potential for WMC growth when considering the need to tackle climate change and growing consumer interest in "green and responsible construction". Enhancing a greener image of the entire construction sector is a fundamental issue for the building companies, and this could be supported by increasing utilization of wood as the main material in structures and facades, or wood to be used as a combination of other materials such as concrete or steel in hybrid solutions, like suggested in Wang. *et al.* (2014).

In addition, although previous studies have found issues in governmental regulation to be an important factor in mobilizing the future potential of WMC (e.g. Mahapatra *et al.* 2012, Wang *et al.* 2014, Hurmekoski *et al.* 2015, Hurmekoski *et al.* 2018), these issues gained much less attention among the experts in our study. Instead, discussion concerning the regulatory framework was mostly related to procedures that the WMC sector actors themselves have more control over, such as construction system development. This may be related to the fact that most governmental regulatory barriers for the diffusion of WMC have now been removed in these countries. Instead of changes in legislation, the WMC sector's future potential is more of a responsibility of the sector itself via developing technical infrastructures (i.e., technologies) and embedded in WMC business networks (i.e., interactions between actors, reshaping standards, and developing firm-specific capabilities).

In reference to the theoretical framework employed, our results showed that using MLP combined with institutional aspects can help to explain the importance of various internal and external factors affecting the competitiveness and the potential for business renewal in the construction industry. However, neither institutional theories, nor MLP provide detailed approaches for identifying the interconnectedness of various institutions when aiming to move from one regime to another. For

example, in the case of WMC, the importance of regulatory barriers for business renewal has diminished, and progress towards the socio-technical regime level is more strongly influenced by internal factors such as the standardization of skills and complementary knowledge base. Yet, due to path dependencies, previous external regulatory barriers still affect the potential for internal skills development within business networks: if a certain technology or material choice is prohibited by regulation at some point in time, it is likely to cast a long shadow on professional education and the industry culture. However, interlinkages between governmental regulation (control of external impacts) or the standardization of skills and knowledge (control of internal impacts) are only one example of the potential application area for developing new theoretical approaches, and future research should aim to also identify other application areas.

**Conclusions**

From theoretical perspective, we used the MLP approach at the interface of construction and wood industries in analyzing the internal and external factors of competitiveness that are shaping the future of WMC. We assumed that influential institutions in the WMC domain are to some degree illustrative of a regime change potential toward the future in more general, and on how re-structuring business networks could partly solve the issue of WMC being a narrow strategic niche. To this end, we applied a dissensus-based Delphi approach to enable mapping as large a variety of opinions as possible, and eventually to identify key internal and external factors of competitiveness.

Our results illustrate the key importance of educating architects and builders and the role of standardized building systems to gain better cost efficiency in WMC, which are falling within the external factor category of “Formal standardization initiated by the industry” by Kadefors (1995), and within the internal factor categories of “Standardization of skills and knowledge” and “Learning and routines” (see Table 1). Instead, the remaining two categories from Kadefors (1995),

"Governmental regulation" (external factor) and "Roles and interest organizations" (external factor), were emphasized less in our study.

From a practical perspective, our results indicate that collaboration and R&D (as internal factors of competitiveness) in the business networks is a fundamental issue for promoting the growth and competitiveness of the WMC sector in the future. In re-organizing their business networks, companies are at the beginning of their learning curves, which causes challenges to establish regime level communities or standardization of products, but which also provides some promising opportunities like re-engineering construction processes. These findings appear to be in line with a recent study by Hurmekoski *et al.* (2018), which concluded that the main potential for wood construction growth comes from industrial prefabrication, often linked with large-scale building projects. In a case study of the city of Gothenburg, Esteban and Jaaniso (2016) also found that successful introduction of WMC solutions into urban construction requires intense collaboration between the public and private sectors, and academia.

We conclude that towards 2030, the institutional stickiness and strong cognitive rules founded in the concrete-based building culture are likely to inhibit the WMC market diffusion. We also welcome a change in the WMC business culture towards a more collaborative mindset that could better capitalize on the emerging niche innovations. The formation of new alliances between large incumbents and new small players in the ecosystem are likely to play a much more important role towards 2030 to enable WMC market share growth. Therefore, factors enabling formation of alliance partnerships to share the risks in WMC projects is an area that merits further investigation. Construction companies are also increasingly concerned with establishing closer connections to customers and end-users, which have traditionally been weak in the field (see also discussion in Bygballe and Ingemansson 2014). Studying end-user needs and user-driven innovations in promoting the business case of WMC therefore constitutes another interesting area for future research.

**Acknowledgements**

We are thankful for the feedback of four anonymous reviewers of this journal. Financial support from the Academy of Finland (Grant 307480), and Tekes 642/31/2016, is gratefully acknowledged.

**References:**

Acur, N., Kandemir, D. and Boer, H. 2012. Strategic alignment and new product development: Drivers and performance effects. *The Journal of Product Innovation Management*, **29**(2), 304–318.

Andrews-Speed, P. 2016. Applying institutional theory to the low-carbon energy transition. *Energy Research & Social Science* **13**, 216–225. https://doi.org/10.1016/j.erss.2015.12.011

Barney, J.B. 1986. Strategic factor markets: expectations, luck, and business strategy. *Management Science*, **32**(10), 1231–1241.

Beckert, J. 2010. Institutional isomorphism revisited: Convergence and divergence in institutional change. *Sociological Theory*, **28**(2), 150–166.

Betts, M. and Ofori, G. 1994. Strategic planning for competitive advantage in construction: The institutions. *Construction Management and Economics*, **12**(3), 203–217.

Blayse, A. M. and Manley, K. 2004. Key influences on construction innovation. *Construction Innovation*, **4**(3), 143–154.

Blind, K., Cuhls, K. and Grupp, H. 2001. Personal attitudes in the assessment of the future of science and technology: a factor analysis approach. *Technological Forecasting & Social Change*, **68**(2), 131–149. DOI: 10.1016/S0040-1625(00)00083-4

Bosman, R. and Rotmans, J. 2016. Transition Governance towards a Bioeconomy: A Comparison of Finland and the Netherlands. *Sustainability* **8**, 1017; doi:10.3390/su8101017.

Bresnen, M., Edelman, L., Newell, S., Scarbrough, H. and Swan, J. 2003. Social practices and the management of knowledge in project environments. *International Journal of Project Management*, **21**(3), 157–166.

Bygballe, L. and Ingemansson, M. 2014. The logic of innovation in construction. *Industrial Marketing Management*, **43**, 512–524

Carter, J. 1967. Components and architect. RIBA Journal, November: 476–477.

Darko, A., Zhang, C. and Chan, A. 2017. Drivers for green building: A review of empirical studies. *Habitat International*, **60**, 34-49.

DiMaggio, P. and Powell, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, **48**(2), 147-160.

Dolata. U. 2009. Technological innovations and sectoral change – Transformative capacity, adaptability, patterns of change: An analytical framework. *Research Policy*, **38**, 1066–1076.

Drejer, I. and Lund Vinding, A. 2006. Organisation, 'anchoring' of knowledge, and innovative activity in construction. *Construction Management & Economics*, **24**(9), 921 - 931.

Dubois, A. and Gadde, L.-E. 2002. The construction industry as a loosely coupled system: implications for productivity and innovation. *Construction Management and Economics*, **20**(7), 621–631.

Elenkov, D. S. 1997. Strategic uncertainty and environmental scanning: the case for institutional influences on scanning behavior. *Strategic Management Journal*, **18**(4), 287–302

Eriksson, P. E. 2013. Exploration and exploitation in project-based organizations: Development and diffusion of knowledge at different organizational levels in construction companies. *International Journal of Project Management*, **31**(3), 333-341.

Esteban, D. and Jaaniso, I. 2016. The impact of sustainable materials on construction innovation: the case of timber in Gothenburg. Department of Technology Management and Economics, Chalmers University of Technology, Sweden. Report No. E 2016:038

European Commission. 2011. Roadmap to a Resource Efficient Europe, COM/2011/571.

European Commission. 2012. Innovating for sustainable growth: a bioeconomy for Europe. Communication from the Commission: COM (2012) 60 final; p. 6–15.

Forest Sector Technology Platform. 2012. Horizons - Revised vision 2030 for the European forest-based sector. The European Forest-38 based Sector Technology Platform.

Fuenfschilling, L. and Truffer, B. 2014. The structuration of socio-technical regimes – Conceptual foundations from institutional theory. *Research Policy*, **43**(4), 772–791. https://doi.org/10.1016/j.respol.2013.10.010

Gann, D. M. and Salter, A. J. 2000. Innovation in project-based, service-enhanced firms: the construction of complex products and systems. *Research Policy*, **29**(7–8), 955–972.

Geels, F. W. 2002. Technological transitions as evolutionary configuration processes: A multi-level perspective and a case-study. *Research policy*, 31(8/9), 1257–1274.

Geels, F. W. 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, **33**(6), 897–920.

Geels, F. W. and Schot, J. 2007. Typology of social transition pathways. *Research Policy*, **36**, 399–17.

Gracht, von der H. A. 2012. Consensus measurement in Delphi studies review and implications for future quality assurance. *Technological Forecasting & Social Change*, **79**, 1525-1536.

Gupta, U.G. and Clarke, R.E. 1996. Theory and applications of the Delphi technique: a bibliography (1975–1994). *Technological Forecasting & Social Change*, **53**(2), 185–211.

Hallowell, M. and Gambatese, J. 2010. Qualitative Research: Application of the Delphi Method to CEM Research. *Journal of Construction Engineering and Management*, **136** (1), 99-107.

Hatcher, T. and Colton, S. 2007. Using the internet to improve HRD research: the case of the web-based Delphi research technique to achieve content validity of an HRD-oriented measurement. *Journal of European Industrial Training* 31(7), 570–587. DOI: 10.1108/03090590710820060

Hatush, Z. and Skitmore, M. 1987. Criteria for contractor selection. *Construction Management and Economics*, 15(1), 19 - 38.

Hawawini, G., Subramanian, V. and Verdin, P. 2003. Is performance driven by industry- or firm-specific factors? A new look at the evidence. *Strategic Management Journal*, **24**(1), 1–16.

Helfat, C. E. and Martin, J. A. 2015. Dynamic managerial capabilities: Review and assessment of managerial impact on strategic change. *Journal of Management*, **41**(5), 1281–1312.

Hemström, K., Gustavsson, L. & Mahapatra, K. 2017. The sociotechnical regime and Swedish contractor perceptions of structural frames. *Construction Management and Economics*, **35**, 184-195.

Holt, G. D. 2013. Construction business failure: Conceptual synthesis of causal agents. *Construction Innovation*, **13**(1), 50–76.

Hung, H.-L., Altschuld, J.W. and Lee, Y.-F. 2008. Methodological and conceptual issues confronting a cross-country Delphi study of educational program evaluation. *Evaluation and Program Planning*, **31**(2), 191–198.

Hurmekoski, E., Jonsson, R. and Nord, T. 2015. Context, drivers, and future potential for wood-frame multi-story construction in Europe. *Technological Forecasting and Social Change*, **99**, 181–196.

Hurmekoski, E., Pykäläinen, J. and Hetemäki, L. 2018. Long-term targets for green building: Explorative Delphi backcasting study on wood-frame multi-story construction in Finland. *Journal of Cleaner Production*, **72**, 3644-3654.

Kadefors, A. 1995. Institutions in building projects: Implications for flexibility and change. *Scandinavian Journal of Management*, **11**(4), 395 - 408.

Ketchen, D. J. and Hult, G. T. M. 2007. Bridging organization theory and supply chain management: The case of best value supply chains. *Journal of Operations Management*, **25**(2), 573 - 580.

The Land Use and Building Act (132/1999)

Lähtinen, K. 2007. Linking resource-based view with business economics of woodworking industry: earlier findings and future insights. *Silva Fennica*, **41**(1): 149–165.

Lähtinen, K. & Toppinen, A. 2008. Financial performance in Finnish large and medium-sized sawmills: the effects of value-added creation and cost-efficiency seeking. *Journal of Forest Economics*, **14**(4): 289–305.

Landeta, J. 2006. Current validity of the Delphi method in social sciences. *Technological Forecasting & Social Change*, **73**(5), 467–482. DOI: 10.1016/j.techfore.2005.09.002

Mahapatra, K. and Gustavsson, L. 2008. Multi-storey timber buildings: breaking industry path dependency. *Building Research & Innovations*, **36**(6), 638–648.

Mahapatra, K., Gustavsson, L. and Hemström, K. 2012. Multi-storey wood-frame buildings in Germany, Sweden and the UK. *Construction Innovation*, **12**(1), 62–85.

Matinaro, V. and Liu, Y. 2017. Towards increased innovativeness and sustainability through organizational culture: A case study of a Finnish construction business. *Journal of Cleaner Production*, **142**, 3184–3193.

Mauri, A.J. and Michaels, M.P. 1998. Firm and industry effects within strategic management: An empirical examination. *Strategic Management Journal*, **19**(3): 211–219.

Meyer, J. W., and Rowan, B. 1977. Institutionalized organizations: Formal structure as myth and ceremony. *American journal of sociology*, **83**(2), 340-363.

Morse, J.M., Barret, M., Mayan, M., Olson, K. and Spiers, J. 2002. Verification Strategies for Establishing Reliability and Validity in Qualitative Research. *International Journal of Qualitative Research*, **1**(2): 13–22.

Nordin, F., Öberg, C., Kollberg, B. and Nord, T. 2010. Building a new supply chain position: an exploratory study of companies in the timber housing industry. *Construction Management and Economics*, **28**(10), 1071–1083.

Porter, M.E. 1985. Competitive Advantage – Creating and Sustaining Superior Performance. The Free Press, NewYork, 557 pp.

Pulkka, L., Ristimäki,M., Rajakallio, K. and Junnila, S. 2016. Applicability and benefits of the ecosystem concept in the construction industry. *Construction Management and Economics*, **34**(2), 129–144.

Rohracher, H. 2001. Managing the technological transition to sustainable construction of buildings: A Socio-technical perspective. *Technology Analysis & Strategic Management*, **13**(1): 137–150.

Roy, R., Low, M. and Waller, M. 2005. Documentation, standardization and improvement of the construction process in house building. *Construction Management and Economics*, **23**(1), 57 – 67.

Roos, A., Woxblom, L. and McCluskey, D. 2010. The influence of architects and structural engineers in timber in construction - perceptions and roles. *Silva Fennica, 44*(5), 871–884.

Rowe, G. and Wright, G. 1999. The Delphi technique as a forecasting tool: issues and analysis. *International Journal of Forecasting*, **15**(4), 353–375.

Rowe, G. and Wright, G. 2011. The Delphi technique: Past, present, and future prospects — Introduction to the special issue. *Technological Forecasting & Social Change*, **78**(9), 1487–1490.

Scott, W. R. 2008. Approaching adulthood: the maturing of institutional theory. *Theory and Society*, **37**(5), 427 - 442.

Segerstedt, A. and Olofsson, T. 2010. Supply chains in the construction industry. *Supply Chain Management: An International Journal*, **15**(5), 347–353.

Steinert, M. 2009. A dissensus based online Delphi approach: An explorative research tool. *Technological Forecasting & Social Change*, **76**, 291-300.

Toppinen, A., Röhr, A., Pätäri, S., Lähtinen, K. & Toivonen, R. 2018. The future of wooden multistory construction in the forest bioeconomy – a Delphi study from Finland and Sweden. *Journal of Forest Economics*, **31**, 3-10.

Wang, L., Toppinen, A. & Juslin, H. 2014. The use of wood in green building: A study of expert perspectives from the UK. *Journal of Cleaner Production*, **65**, 350-360.

Weber, K.M. & Schaper-Rinkel, P. 2017. European sectoral innovation foresight: Identifying emerging cross-sectoral patterns and policy issues. *Technological Forecasting & Social Change*, **115,** 240 – 250.

Winkler, J. & Moser, R. 2016. Biases in future-oriented Delphi studies: A cognitive perspective. *Technological Forecasting & Social Change*, **105,** 63-76.

Vermeulen, P., Büch, R. and Greenwood, R. 2007. The Impact of Governmental Policies in Institutional Fields: The Case of Innovation in the Dutch Concrete Industry. *Organization Studies*, **28**(4), 515 – 540.

Zucker, L.G. 1987. Institutional theories of organization. *Annual Review of Sociology*, **13**, 443 - 464.